

WHY STUDY HUMAN HEALTH INDOORS?

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BACKGROUND

Americans spend about 90 percent of their time indoors, where concentrations of pollutants are often much higher than those outside. Risk assessments performed for radon, environmental tobacco smoke (ETS), and lead have shown that health risks are substantial. Thousands of chemicals and biological pollutants are found indoors, many of which are known to have significant health impacts both indoors and in other environments. Although much is known or suspected regarding human health risks in the indoor environment, a comprehensive, integrated effort to assess and manage indoor risks has yet to be undertaken.

In 1987, the EPA Comparative Risk Project was conducted to examine the relative risk of environmental problems. In 1990, the Relative Risk Reduction Strategies Committee of EPA's Science Advisory Board conducted a similar, extensive analysis of relative environmental risk. Both resulting reports, *Unfinished Business: A Comparative Assessment of Environmental Problems* (U.S. EPA 1987) and *Reducing Risk: Setting Priorities and Strategies for Environmental Protection* (U.S. EPA 1990), ranked indoor air pollution among the top five environmental risks to public health. In 1997, the Presidential and Congressional Commission on Risk Assessment and Risk Management also found that indoor environmental pollution can pose a substantial environmental risk and advised EPA to address those risks. During the release of its report, the Commission chairman highlighted indoor environmental pollution as one of the greatest risks to human health.

Americans are concerned about their own health and the health of their children. However, despite efforts by EPA and other private and public groups to conduct research on indoor environmental issues and to communicate the findings of that research, most Americans do not have a clear sense of the significant health risks of indoor pollution. They also do not know what they can do to reduce risk for asthma, cancer, and other serious diseases caused by indoor pollutant exposure.

Nor do many building professionals yet understand how to integrate indoor air quality objectives into the design and operation of the Nation's buildings. The economic value of improved health and productivity can be substantial, and can be achieved through integrated building design, commissioning, and operations which may reduce costs or result in only modest cost increases. Thus, indoor air quality promises to become an important part of the movement toward green buildings and green products. Further, any productivity gains will serve to enhance the Nation's competitiveness in the global economy.

PRINCIPLES FOR HBHP

The following two principles will serve to provide a workable context for identifying and addressing priorities for improving the indoor environment:

First, exposure needs to occur within or be aggravated by the building.

This principle is relatively straightforward. However, there are diverse types of buildings, including homes, schools, day care facilities, nursing homes, offices, factories, hospitals, hotels, restaurants, retail shops, theaters, arenas, and correctional facilities. Impacts on human health and methods for reducing exposure to indoor air pollution and the associated risk vary by building type, use, and activity.

Second, risk reduction must be accomplished through better building design, construction, and operation; improvements in the development and use of indoor products; or mitigation of existing exposures within a building or in its immediate vicinity.

This principle excludes some risks that, although they occur indoors, originate outside the building and are best mitigated at a distance. For example, risks would be excluded if the source of the pollutant is industrial discharge (e.g., drinking water contaminated by lead tailings from a mine or air pollutants entering the environment from industrial smokestacks¹). Risks would be included when the pollutant is added indoors (e.g., drinking water contaminants from lead solder in plumbing in the building or air pollutants emitted from sources within the building). Pesticide residues on food from the spraying of crops would be excluded, while pesticides used directly indoors, or that are used near the home and are tracked indoors, would be considered indoor pollution.

INDOOR HUMAN HEALTH RISKS

The risks to human health indoors include asthma, cancer, reproductive and developmental problems, and other health effects.

Exposures to radon, ETS, lead, and other chemical and biological contaminants in the indoor environment result in a wide array of health impacts. Known health effects of indoor pollutants include asthma; cancer; developmental defects and delays, including effects on vision, hearing, growth, intelligence, and learning; and effects on the cardiovascular system (heart and lungs). Pollutants found in the indoor environment may also contribute to other health effects, including those of the reproductive and immune systems. Some pollutants, such as carbon monoxide (CO), are acutely toxic and can result in death. The following sections summarize several health endpoints of greatest concern.

ASTHMA

An estimated 17 million Americans suffer from asthma (U.S. EPA 1999). In addition, about 5,000 deaths occur yearly from asthma—an increase of 33 percent in the last decade (Mannino et al. 1998). Consequently, the social and economic costs are large. Among chronic diseases, asthma is the number one cause of absenteeism from school (Pope et al. 1993). Asthma cost an estimated \$6.2 billion in the United States in 1990, including direct medical and indirect non-medical costs combined (Weiss et al. 1992). An update of this figure would fall in the range of \$7 to \$9 billion in 1998 dollars.

Some groups in this country (e.g., children, certain minorities, seniors, and low-income, urban populations) are disproportionately affected by asthma. An estimated 1.8 million people required emergency room services for asthma in 1995. Mortality rates associated with asthma among African-Americans, as a whole, are two- to three-fold higher than those among whites. Mortality rates for African-American children are five-fold higher than those for their white peers (Mannino et al. 1998). While research has not yet explained the rise in the incidence of asthma, nor all the reasons why individuals first contract it, there is general agreement that controlling indoor exposures is an important protective measure (NAS 2000).

Recently, the National Academy of Sciences (NAS)/Institute of Medicine issued a report on asthma and indoor air quality, confirming that dust mites and other allergens, microorganisms, and some chemicals found indoors are triggers for

asthma. In addition, the report stated there was sufficient evidence to link the exposure of preschool-aged children to ETS and exposure to house dust mites with the development of asthma (NAS 2000). ETS may significantly aggravate symptoms of asthma for 200,000 children and may affect as many as 1,000,000 children to some extent (U.S. EPA 1992).

CANCER

A number of indoor contaminants, such as asbestos, radon, tobacco smoke, and benzene, are known human carcinogens. Other indoor contaminants, such as certain chlorinated solvents, polycyclic aromatic hydrocarbons, aldehydes, and pesticides, are considered likely to cause cancer in humans.

The National Academy of Sciences, in its latest report on radon health science (NAS 1998), concluded that radon is the second leading cause of lung cancer in the country. NAS has estimated that about 12 percent of the lung cancer deaths in the United States are linked to radon. They calculate the number of lung cancer cases attributable to radon exposure to range from 15,000 to 22,000 annually.

Environmental tobacco smoke is estimated to cause an additional 3,000 lung cancer deaths in non-smokers each year (U.S. EPA 1992).² Other forms of cancer have also been found to be associated with indoor pollutants (e.g., leukemia with benzene; bladder cancer with ETS).

REPRODUCTIVE AND DEVELOPMENTAL EFFECTS

During the period 1991-1994, almost 900,000 children aged 1-5 years had elevated blood lead levels, which are associated with a variety of developmental delays, including decreased intelligence quotient (IQ); stature, growth, and hearing deficits; and learning disabilities (U.S. DHHS 1997a). The geometric mean blood lead level for children aged 1-5 years was 2.7 ug/dl in 1991-1994. In 1999, the geometric mean was estimated to be 2.0 ug/dl for this age group. The 1999 sample was not large enough to produce reliable estimates of the number of children with elevated blood lead levels. State surveillance data are consistent with the decline in the national geometric mean, but the state data also confirm

that the risk for an elevated blood lead level in children remains high in some counties and varies greatly among and within states (U.S. DHHS 2000). Several studies indicate that common indoor pollutants such as lead and ETS can also impair fetal development. A California report estimates that 9,700 to 18,600 cases of low birth weight in infants are caused each year by ETS (NCI 1999).

Many other environmental agents, including a number of chemicals commonly found indoors (e.g., tobacco smoke, some pesticides, lead and other heavy metals, alcohols, plastic additives), are suspected of causing developmental toxicity in humans (U.S. EPA 1991a, NCI 1999). Endocrine disruptors (e.g., certain pesticides and plasticizers), which affect the normal function of sex and thyroid hormones, present a new area of concern for reproductive toxicity. Adverse effects on a developing child may result from exposure prior to conception in either parent, exposure during pregnancy, or post-natal exposure. These effects range from low birth weight to genetic diseases to lower IQs and infertility.

OTHER HEALTH EFFECTS

Indoor environments can cause or amplify many other health effects as well. The California ETS report estimates that 35,000 to 62,000 cardiovascular deaths per year among non-smokers can be attributed to ETS exposure (NCI 1999). Recent studies have shown that, compared to those who had not been exposed, ETS was associated with a 20 percent increase in the progression of atherosclerosis (hardening of the arteries) (Howard et al. 1998). Carbon monoxide poisoning associated with the improper use and maintenance of fuel-burning appliances kills more than 200 people per year in this country and results in about 10,000 admissions to hospital emergency rooms for treatment (U.S. CPSC 1997). An additional 600 to 700 accidental deaths from CO poisoning occur indoors from other sources, including automobiles (Cobb and Etzel 1991). The agent for Legionnaires' disease, a potentially deadly pneumonia which affects 10,000 to 15,000 people each year,

is associated with cooling systems, whirlpool baths, humidifiers, food market vegetable misters, and other indoor sources, including residential tap water (EPA et al. 1994; U.S. DHHS 1997b). Effects associated with toxins from indoor fungi and bacteria range from short-term irritation to immunosuppression and cancer (EPA et al. 1994).

Studies show that symptoms of sick building syndrome (SBS) may be caused or intensified by indoor environmental problems (U.S. EPA 1991b, U.S. EPA et al. 1994). The term “sick building syndrome,” first employed in the 1970s, describes a spectrum of specific and non-specific complaints reported by a population of building occupants. These symptoms can be associated with their presence in the building. These complaints may also result from causes other than SBS, including illness contracted outside the building, acute sensitivity (e.g., allergies), job-related stress or dissatisfaction, and other factors. Data are insufficient to thoroughly evaluate many SBS problems.

UNCERTAINTIES

Although EPA has estimated the carcinogenic potency of a number of indoor pollutants, the Agency has conducted comprehensive population risk assessments for only a few substances (e.g., radon, ETS, lead). A comprehensive indoor environments risk assessment should cover all of the chemical and biological indoor pollutants for which sufficient toxicological and exposure data exist.

Most chemicals in commercial use have not been tested for possible health effects. Fewer than one-third of regulated, high-production chemicals, including many found indoors, have undergone even a screening level of testing for adverse effects. Health effects data are particularly critical for indoor exposure because median indoor concentrations are one to five times the median outdoor concentrations of many hazardous air pollutants. Considering that people spend approximately 90 percent of their time indoors, median indoor exposures (concentration multiplied by time) may be 10 to 50 times higher than outdoor exposures (U.S. EPA 1998).

Significant uncertainties exist in the areas of exposure assessment and control. For example, data are lacking on the rate and frequency of emissions from many sources, such as building materials and consumer products. There is also a lack of data on the identity of the chemicals emitted, as well as on the cost and performance of solutions to reduce exposures. While there are standard methods to quantify emissions from certain types of products and materials (e.g., carpets, office furniture, paints), many more are needed to facilitate widespread commercial development of new products and materials that emit significantly lower levels of indoor pollutants. Significant uncertainties still exist regarding how a change in building design, operation, and maintenance will influence the mix of indoor pollutants, as well as how to measure the concentrations of biological contaminants present indoors. Exposures in schools, residences, and most other non-occupational indoor environments still remain largely unstudied.

WHO IS MOST AT RISK?

Children often experience higher exposures to environmental pollutants than adults because, per pound of body weight, they breathe more air and ingest more material than adults. Children also more readily absorb contaminants. Additional exposure pathways resulting from activities such as crawling and sucking and gnawing on toys can also elevate risk for children. For example, between 1991 and 1994, almost 900,000 children in this country had unacceptable blood lead levels from exposure in their own homes (U.S. DHHS 1997a). Minority status, income status, and age of housing have all been shown to correlate with elevated blood lead in children. Children are more susceptible to the effects of lead exposure because their brains are still developing, they ingest more lead than adults through hand-to-mouth activity, and their developing systems more readily absorb lead than those of adults (U.S. EPA 1996).

EPA estimates that ETS is responsible for between 150,000 and 300,000 lower respiratory tract infections in infants and children under 18 months of age, as well as an increased prevalence of fluid build-up in the middle ear. This is estimated to result in between 7,500 and 15,000 hospitalizations each year. Post-natal ETS exposure has also been implicated in 1,900 to 2,700 cases of sudden infant death syndrome (SIDS) annually (NCI 1999).

Individuals may be more vulnerable to indoor contaminants because of age, genetics, nutrition, metabolism, exposure levels, existing diseases, and other factors. For example, older people are at particular risk for adverse effects on the nervous and cardiovascular systems; asthmatics are more vulnerable to allergens and respiratory irritants; and people with acquired immune deficiency syndrome (AIDS) and other immunodeficiencies are more vulnerable to pneumonia, pathogenic yeasts, and other illnesses.

¹When attempting to reduce the “total” impact on human health, knowledge of the relative risk from ambient air pollutants that make their way indoors and from pollutants emitted by indoor sources will determine the focus of where the most effective risk reduction can occur.

²A U.S. District Court decision vacated several chapters of EPA’s 1993 scientific risk assessment document that served as the basis for EPA’s classification of secondhand smoke as a Group A carcinogen and estimates that ETS causes 3,000 lung cancer deaths in non-smokers each year. The ruling was largely based on procedural grounds. EPA is appealing this decision. None of the findings concerning the serious respiratory health effects of secondhand smoke in children was challenged.

EPA firmly maintains that the bulk of the scientific evidence demonstrates that ETS causes lung cancer and other significant health threats to children and adults. EPA’s 1993 report estimating the risks posed by ETS was peer-reviewed by 18 eminent, independent scientists who unanimously endorsed the study’s methodology and conclusions. Since then, numerous independent health studies have presented an impressive accumulating body of evidence that confirms and strengthens the EPA findings. It is widely accepted in the scientific and public health communities that secondhand smoke poses significant health risks to children and adults.